

First Year Interim Progress Report for Period 8/15/2005 - 11/15/2005

Automated Classification of X-ray Sources for Very Large Datasets

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The period of performance for this AISRP grant is November 1, 2004 thru October 31, 2006. Research on this grant began in late August of 2005, after the PI was hired at the Rochester Institute of Technology. A 12-month extension will be requested for this project.

Introduction

A large fraction of Chandra and XMM-Newton observing time has been devoted to the study of young star clusters and, as a consequence, large datasets exist from these observations of rich stellar fields. A typical Chandra or XMM-Newton CCD observation of a young stellar cluster results in detection of X-ray emissions from tens to hundreds of very young stars. Spectral and temporal data is available from these observations. A wide range of temporal behavior has been detected in X-ray sources. This temporal behavior ranges from long-term flaring to episodic, short X-ray bursts.

Our objective is to develop an algorithm will make use of both spectral data and temporal properties to group and classify discrete sources of X-ray emission. This new method will handle large quantities of data and operate independently of the requirement of source models (spectral or temporal) and a priori knowledge concerning the nature of the sources (i.e., young stars, interacting binaries, active galactic nuclei). This unbiased approach could lead to the discovery of new classes of sources that do not fit any existing models and X-ray sources that are extreme outliers in the spectral and/or temporal domains.

Summary of Progress

Previously, our source classification algorithm was run with spectral data from archival images of the Orion Nebula Cluster (ObsIds 18 and 1522). A 'clean' subset of the Chandra Orion Ultradeep Project (COUP; ObsIds 3744, 4373, 4374, 4395, and 4396) was selected for use in developing the algorithm. COUP is a ~10.2 day exposure of the Orion Nebula Cluster obtained in January 2003. Extremely faint sources and sources with pileup or other source detection problems were not included in the subset. Background correction was applied to the COUP subset. The existing source classification algorithm was run on the COUP subset. Seventeen X-ray classes, including one outlier class, were created from the algorithm. These X-ray classes are in order of decreasing spectral hardness. In addition, trends exist between X-ray spectral parameters and stellar parameters for very low-mass, soft spectra, young sources. Correlations between these softer X-ray spectral classes and the classical optical spectral types can be seen.

Currently, we are using the X-ray spectral classes obtained from running the algorithm on the COUP subset to classify the remainder of the ~1150 sources in the full COUP dataset. Several techniques to classify the remaining sources are currently being tested. Each source will have a class membership probability associated with it. The results of running the algorithm on the entire COUP dataset will be presented at the 207th American Astronomical Society Meeting on January 9, 2006 in Washington, DC (Hojnacki et al. 2005, BAAS, vol 37, in press).

Furthermore, we have been working with a team of researchers at the Harvard-Smithsonian Center for Astrophysics (CfA) to obtain X-ray spectral and light curve data of star formation regions. A catalog of young stellar clusters is being created by the CfA, with the goal of providing a database for which uniform data analysis and processing methods have been used for all data in the database. This web-based catalog is called the Archive of Chandra Observations of Regions of Star Formation (ANCHORS). Our algorithm will be tested against other star formation regions from this archive, to ascertain whether the results from the Orion Nebula Cluster generalize to other young stellar clusters. X-ray source classes resulting from our algorithm may be included in a future version of the ANCHORS database.

Meeting with Collaborator

Giusi Micela is an astronomer at the Observatory in Palermo and a collaborator on this grant. She is co-leader of the X-ray Spectra and Variability Group on COUP and is currently part of a group of scientists studying variability of X-ray sources and characterization of that variability. In November, we met with Giusi Micela and Salvatore Sciortino (also from the Observatory at Palermo) in Boston. We discussed algorithms that can be used to characterize the X-ray flares and variability of each source. These algorithms break the X-ray light curve into blocks to characterize the location, amplitude, duration, and periodicity of fluctuations in the light curve data. We also discussed various parameters that can be used as input into the source classification algorithm. Finally, we talked about possible simulations that could be run before acquiring actual data.

Plans for Upcoming Year

We will study the relationships between X-ray spectral classes and X-ray temporal classes to establish spectral and temporal diagnostics that can distinguish between potential X-ray emission mechanisms, i.e., stellar coronal activity versus star-disk interactions. Additional work includes continuing to study previous astronomical studies on X-ray temporal analysis to identify approaches that have proved successful. Previous studies have generally involved one X-ray source.

X-ray light curve parameters will be chosen and added as inputs to the algorithm. The algorithm will then be run with temporal inputs for each source, to search for natural groupings of the X-ray sources and handle fainter sources by inclusion of source variability properties. Interim results from this phase will be submitted for publication in mid-2006.

Finally, our spectral/temporal classification algorithm will be run on star formation regions other than Orion, to develop and test the ability to cluster sources in other regions of the sky using information learned from previous source clusterings.